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ABSTRACT

The objective of this Congress was to consider the role science and technology is called upon to play in national development and its relevance to specific needs of member states, particularly with respect to endogenous development. The first section focuses on the role of science and technology education (STE) in national development, discussing: contribution of STE to national goals; contribution of STE to solving major contemporary problems related to development; future trends in STE and their implications for STE related to national development; and implications of the UNCSTD conference for education in science and technology. The second section focuses on strategies for improving STE in relation to development, addressing: contribution of education in building a favorable climate for development/application of science and technology; STE in the perspective of development needs; development of content, methods, and materials for STE; and promotion of the endogenous development of STE. The next section considers international cooperation, discussing: main issues/objective of international cooperation in STE and main areas and methods of international cooperation in this field, role of Unesco and other organizations; and contribution of non-governmental organizations in extending and improving STE, emphasizing developing countries. Suggestions for future action are provided in the final section. (JN)

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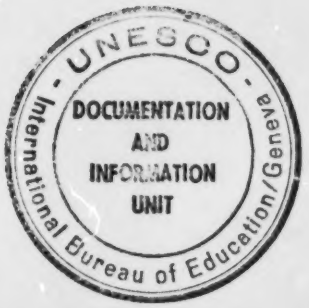
UNITED NATIONS EDUCATIONAL
SCIENTIFIC AND CULTURAL ORGANIZATION

# INTERNATIONAL CONGRESS ON SCIENCE AND TECHNOLOGY EDUCATION AND NATIONAL DEVELOPMENT

Paris, 23 November - 2 December 1981

## FINAL REPORT

ED-81/Conf.401/Col.10



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# INTRODUCTION

## Opening Ceremony

1. The Congress was opened, on behalf of the Director-General of Unesco, by Mr. S. Tanguiane, Assistant Director-General for Education, who welcomed participants and observers from 81 Member States and representatives and observers of international governmental and non-governmental organizations. He indicated that the organization of the Congress had been foreseen in Unesco's current programme and budget as a follow-up to the United Nations Conference on Science and Technology for Development which was held in Vienna in 1979, and in the context of Unesco's action on prospective thinking in the field of education. The objective of the Congress was to consider the role science and technology education is called upon to play in national development and its relevance to the specific needs of Member States, particularly in respect of endogenous development. Mr. Tanguiane stated that the meeting would review present achievements in science and technology education and would formulate, in a forward-looking spirit, guidelines for the development of the teaching of basic sciences and technology at primary, secondary and higher levels of education as well as in the non-formal education of the general public. The meeting would also consider ways and means of strengthening national infrastructures for research and training in science and technology education and the development of appropriate curricula and teaching materials, with particular attention to the needs of developing countries and international co-operation in this field.

2. The meeting elected the following officers:

| | |
|---|---|
| Chairman | Dr. Rais Ahmed<br>Professor, Physics Department<br>Aligarh Muslim University<br>India |
| Vice-Chairmen | Mr. V.G. Razumovski<br>Academician<br>Secretary of the Section of Didactics and Methodology of the Academy of Pedagogical Sciences<br>USSR |
| | Dr. David Lockard<br>Director, Science Teaching Centre<br>University of Maryland<br>USA |
| | Mr. C.E. Chimombe<br>Headmaster, Fletcher High School<br>Zimbabwe |
| Rapporteur | Dr. George Za'rour<br>Director, Science and Mathematics Education Centre<br>American University of Beirut<br>Lebanon |

| | |
|---|---|
| Vice-Rapporteur | Dr. Winston King<br>School of Education<br>University of the West Indies<br>Barbados |
| | Commission 1 |
| Chairman | Professor C.A. Taylor<br>University College Cardiff<br>United Kingdom |
| | Commission 2 |
| Chairman | Ms Myriam Krasilchik<br>Director, Centre for the Training of Science Teachers<br>São Paulo<br>Brazil |
| | Commission 3 |
| Chairman | Professor Gyula Soos<br>University of Eotovos Lorand<br>Hungary |
| | Commission 4 |
| Chairman | Dr. Djibril Fall<br>Department of Physics<br>University of Dakar<br>Senegal |

3. Mr. S.R. Samady, Director of the Division of Science, Technical and Vocational Education, and Secretary-General of the Congress, explained that the organization of work provided time for discussion both in plenary session and in four commissions. He indicated that the working documents included a 'Discussion Guide' outlining aspects of the various programme items that might receive particular attention. A detailed working paper had been prepared as a basis for the work of the four commissions.

Work of the Congress

4. The Congress first discussed, in two plenary sessions, item 5 'The role of science and technology education in national development'. After an introduction by the Chairman, the discussion in the first of these sessions was opened by a panel of four speakers consisting of Professor D. Fall (Senegal), Professor K. Frey (Federal Republic of Germany), Dr. D. Hernandez (Philippines) and Professor G. Marx (Hungary). The discussion covered the following two topics -- 'National development goals: the contribution of science and technology education' and 'The contribution of science and technology education to the solution of some major contemporary problems in relation to development'. Twenty-one speakers spoke on this item.

5. The second plenary discussion on item 5 covered the topics 'Future trends in science and technology in the context of national development' and 'Implications of the UNCSTD Conference for education in science and technology'. The Chairman opened the discussion on these items and his introduction was followed by a panel consisting of Professor Bénard (France), Academician Razumovski (USSR) and Dr. K. Awuku (Ghana). Eleven speakers contributed to the discussion that followed.

6. Item 6 -- 'Strategies for the improvement of science and technology education in relation to development, including suggestions for future action' was first discussed in two plenary sessions and was subsequently taken up in four commissions. In the first plenary session, a general introduction to the item was given by the Chairman, followed by contributions from the Chairmen of Commissions 1 and 2. Fourteen speakers contributed to the discussion that followed. In the second plenary session, the discussion was opened by the Chairmen of Commissions 3 and 4, and 16 speakers contributed to it.

7. The four commissions were established on the afternoon of Wednesday, 25 November and completed their work on Saturday, 28 November. They covered the following topics and elected the following additional officers:

| | | |
|---|---|---|
| Commission 1 | The contribution of education to building up a favourable climate for the development and application of science and technology | |
| | Vice-Chairman: | Professor Pei-Ji Xia (People's Republic of China) |
| | Rapporteur: | Professor G. Eshiwani (Kenya) |
| Commission 2 | Science and technology education in the perspective of development needs | |
| | Vice-Chairman | Dr. Radomir Silin (Ukrainian SSR) |
| | Rapporteur | Dr. A.H. Fekih (Tunisia) |
| Commission 3 | Development of content, methods and materials for science and technology education | |
| | Vice-Chairman: | Dr. D.F. Hernandez (Philippines) |
| | Rapporteur: | Dr. R. Tobon (Colombia) |
| Commission 4 | Promotion of the endogenous development of science and technology education | |
| | Vice-Chairman: | Dr. A. Sangster (Jamaica) |
| | Rapporteur: | Dr. G. Orpwood (Canada) |

8. On Monday, 30 November, item 7 'International Co-operation' was discussed in two plenary sessions. The first of these considered some of the main issues and objectives of international co-operation in science and technology education and methods of promoting this co-operation. Some priority fields for such co-operation were also identified. Twenty-three speakers contributed to the discussion. In the second session, the role of Unesco and other organizations of the United Nations system, in international co-operation, was considered. Considerable attention was also devoted to the contribution of other intergovernmental organizations and of non-governmental organizations to the extension and improvement of science and technology education, with special reference to developing countries. Twenty-five speakers contributed to this item.

9. On Tuesday, 1 December, the reports of the four commissions were presented and discussed in plenary session. In the afternoon, suggestions were put forward in plenary session, for future action at national, regional and international levels. Twenty-two speakers contributed. The report of the Congress was adopted on the morning of Wednesday, 2nd December, when the closing ceremony was also held. The address of Mr. S. Tanguiane at this ceremony, on behalf of the Director-General, is appended as Annex II.

## THE ROLE OF SCIENCE AND TECHNOLOGY EDUCATION IN NATIONAL DEVELOPMENT

### Item 5.1 -- National development goals: the contribution of science and technology education

10. Over the last century, countries with a high rate of scientific and technological growth have shown parallel progress in their economic development. This indicates a direct correlation between science and technology, on the one hand, and economic development on the other. The significance of education in the development process, however, is not so clear. Recent studies in one country on farmer populations have shown that farmers with four years of education harvest 8 per cent more than those without such schooling. A study based on the analyses of the economic progress of a large number of countries has also shown the existence of a correlation between economic development and the level of education of the population in the country concerned. Emphasis was placed on the need of science and technology education for change, in particular to improve living standards through appropriate and optimal use of available resources.

11. The attempts of developing countries to modernize agricultural and industrial sectors are hampered by a lack of scientific attitudes in the public at large, and a general shortage of qualified manpower in science and technology. Efforts at developing science and technology have been generally geared to the needs of urban areas. Rural areas where 60-80 per cent of the population of the developing countries reside have not been so fortunate.

12. The relationship between science and technology education and national development can be viewed in two ways. Science and technology education within national development means that science and technology education receives form and purpose within the more encompassing social development. It is not an end in itself, but has a certain position within the whole. This may lead to numerous consequences such as the local and regional form of science and technology education as well as locally determined development strategies.

13. There is, however, not only science and technology education within national development, but rather the conception of science and technology education for national development. This conception conveys a lot of optimism and hope. It also constitutes a motive for the efforts of the United Nations and its organizations in science and technology education.

14. It was suggested that science and technology education at all levels can make a significant contribution to a country's nutritional and primary health care needs. They can also contribute to the fulfilment of human rights proclaimed by the United Nations, particularly, the right to freedom from fear and want, and the right to make use of natural resources in optimal and appropriate ways. It was also felt that science and technology education must help in (i) developing self-reliance (ii) stimulating endogenous growth, and (iii) organizing and planning policy and strategies for rational utilization of natural and human resources in the country. Thus science and technology education must be planned and organized in relation to each country's specific development needs.

15. There was a general emphasis on the need to promote endogenous development of national science and technology systems as well as resources by mobilizing and harmonizing the country's educational, socio-economic and cultural policies. Over the years, various societies have developed a store of knowledge, skills and experiences which have enabled them to survive by harnessing certain aspects of their environment. This traditional lore including handicrafts, trades, farming techniques and other agricultural practices should not be abandoned

altogether in favour of imported modern technologies. Instead, efforts should be made to identify any scientific roots in these traditional practices, and to base future development on them. It is thus a question of building a bridge between what is relevant in the 'old' and the 'modern.'

16. The school should serve as a vehicle for the transfer of such traditional technologies with emphasis on the continuity of the society and its accumulated knowledge, skills and experiences. The teaching of this traditional and cultural heritage, however, must encourage a sense of scientific/technological creativity in relation to the local environment. Efforts need to be exerted to convince teachers of the great importance of encouraging creativity among pupils at all levels.

17. Science and technology are not a panacea for solving all the problems confronting humanity today. If not developed and used with discretion and control, science and technology can prove counter-productive and may even run contrary to the above-mentioned larger goals of realizing human rights and satisfying basic human needs in relation to national socio-economic development. Some negative experiences have been felt during the last few decades. One example relates to misuse of science and technology as an instrument in the selection of 'gifted' students.

18. The qualitative and quantitative improvements in science and technology education must aim to meet actual needs both for the present and future. Improving the quality of science and technology education requires close collaberation with the applied sciences e.g. agriculture and engineering sciences, and also with teacher-training and evaluation techniques.

Item 5.2 -- <u>The contribution of science and technology education to the solution of some major contemporary problems in relation to development</u>.

19. It was unanimously agreed that science and technology, together with the teaching of them through the various types of formal and non-formal education, constituted an essential factor in improving the material and cultural conditions of people's lives and a priority objective of cultural development. It was emphasized that, in the world of today, mastery by a society of scientific and technical knowledge was an essential condition for the assertion of cultural identity and independence and for the promotion of effective participation by the people in determining and implementing collective action for development and thus for ensuring better national control of its results.

20. More specifically it was felt that the development of science and technology and their promotion through education could and should play a vital role in solving the most urgent problems confronting the world, since these problems threaten the conditions and quality of life of vast sectors of the population and the very survival of mankind. Special emphasis was placed on the role of science and technology for developing the productive potential of society, particularly in the full utilization of the human resources and agricultural and industrial activity needed to improve the people's material living conditions, especially in the developing countries. With regard to the problem of rapid population growth, the teaching and application of science and technology could make a significant contribution to the development of the resources needed to meet the requirements of an ever-growing population and could also help to ensure more effective control of population growth rates. Lastly, in this connection, there is the mounting urgency of halting the arms race, not only because it places the entire world under the permanent threat of war and destruction, but also because it diverts enormous

material, financial and human resources -- including highly qualified scientists and technicians -- from the loftier aims of economic and cultural development for the whole of mankind.

21. Education had become significantly more extensive and more specialized as a result of the fact that the contemporary world was characterized by rapid social change and the building up of unprecedented problems necessitating the constant renewal of knowledge for their effective solution. In addition to making it possible to pass on the cultural heritage that enabled the new generation to adjust to the established order, the present role of education is to contribute to development and to the dissemination and use of knowledge -- especially scientific and technological -- so as to help individuals and groups acquire a more flexible and more imaginative grasp of the facts and significance of their natural and social environment.

22. In this context, there is the need to incorporate science and technology into every part of the life of societies as the ideal means of awakening in the new generation a scientific perception of reality, by drawing on the full range of educational resources and means available to the community: systematic instruction, information, and popularization methods. Such incorporation should also make it possible to provide young people with the kind of values and attitudes and the powers of rational thought, expression and behaviour that fostered the development of both the individual personality and of an intellect that could adapt itself to a rapidly changing environment and find the right answers to the unpredictable challenges the future might bring.

23. Care must be taken, in developing science and technology education to ensure that modern knowledge is harmoniously combined with the significant contributions of traditional knowledge, partly for the sake of preserving the achievements of the past which hold promise for the future and are essential to the assertion of national cultural identity, and partly to enable the least privileged countries to incorporate into their living tradition effective scientific knowledge and techniques for solving their present problems and also to pave the way for the qualitative leap needed to reduce the gap separating them from the industrialized countries. There is a need to emphasize here the part that could be played by computer science and information technology to improve national capacities for the management of development, and by bio-technology to meet the basic needs of the population (in nutrition and health, more especially).

24. On a more directly educational note, there is the need to improve the social relevance and effectiveness of education and hence to link science and technology education more closely with the real-life needs of society. Education should be related to the world of work in such a way that pupils, when faced with specific real-life problems, can more easily grasp the connection between theoretical and practical knowledge, acquire the attitudes and aptitudes essential for productive work -- team spirit, sense of responsibility, method, etc. -- take their place in society and thus contribute, from early life, to the collective task of national development. For the same general purpose, science and technology education should be tied in with environmental problems, with a view to fostering individual and collective behaviour patterns that would make for more rational use of natural resources and the long-term preservation of the productive potential of the environment.

25. Finally, it is essential to take account of certain counter-productive effects that could result from science and technology education in certain cases when it was diverted from its goal, which is to give the entire population access to a scientific conception of reality. Care should be taken, it was recommended, to

avoid developing or reinforcing sexist attitudes that might discourage women from taking an interest in certain scientific subjects. Science education should not be used as a measure for the selection of students on the basis of certain formal criteria such as intellectual aptitude; instead, it should bring out the practical aspects of science so as to develop the students' personal independence and ability to solve the practical problems of everyday life and the taste and liking for science that would help it to flourish.

Item 5.3 -- Future trends in science and technology and their implications for science and technology education in the context of national development

26. The fast pace of scientific and technological change was recognized and a distinction was made between (1) the need to cope with specific changes already taking place, and (2) the need to prepare the student to cope in adult life with future changes which are of a basically unpredictable nature. With respect to specific changes, two fields were given particular attention: information processing and biotechnology. Information processing was deemed to introduce a true revolution, having an impact not only of a technical nature, but also on the future pattern of social life. This matter was referred to also in connection with the information explosion, which opens up enormous possibilities as to availability and access to knowledge and information. It poses problems to educational systems forcing them to make choices with respect to subject-matter offerings and to the extent of diversity in the programme. The biosciences were considered important enough for the future of humanity so as to suggest that the twenty-first century will be the 'biology century'. From the educational point of view, biotechnology is recognized as lending itself to the linking of teaching with research. This provides a remedy to a trend which is considered dangerous, namely, the gradual dissociation between teaching and research in many universities of developing countries. In fact, research in some areas within the biosciences does not require very costly equipment and is interesting. Other fields which were considered of importance are: alternative energy sources, fibre optics, ecosciences and ocean sciences.

27. On the matter of preparing students to cope with future change, it was recognized that planning of education had to reckon with the fact that extrapolation entails risks. This implies that educational systems should provide for continued review and adaptation and be able to furnish continuing education at all levels and in every aspect including vocational education. It was noted that this evolutive process calls for a well-designed mechanism of evaluation.

28. To fulfil the need for a certain degree of specialization while giving the student a potential flexibility to adapt for change, it is necessary to reconcile two extreme approaches: unification and deep specialization in the sciences. In general, it was recognized that the growing trend towards unification of scientific knowledge appears to simplify matters when it comes to teaching science. However, the scientific community evolves towards an ever deeper specialization. Thus, driving too far an integrated approach to science education might involve the risk of dispersion and superficiality. With regard to technology education, it may be more difficult to talk about unification at the level of basic concepts; but the pursuance of any technological objective requires multi-disciplinarity and collaboration among specialists -- a fact that should not be disregarded when designing the educational process.

29. To cope with these characteristics of science and technology, it is then necessary, first, to beware of adopting extreme positions. The approach should be, in each case, a function of the situation to be tackled. Second, to use to advantage people of different backgrounds, involving not only scientists and techno-

logists, but also people in the world of work, social scientists, etc., in an attempt to link the educational process to the prevailing context. Third, it is necessary to avoid excessive abstraction, which was considered undesirable in view of the fact that, in everyday life, most people have to deal with concrete problems of realities.

30. The importance of developing rational and analytical attitudes and of promoting the acquisition of the methods of science was considered of long-lasting value in an area of rapid change in addition to its value in shaping a mentality well-adapted to a world increasingly permeated by science and technology. In this respect, much attention was again devoted to the matter, and it was considered to be closely related to the methodology of training and to creating the necessary motivation. Contests, prizes and fairs were given as examples for promoting creativity and excessive directiveness was considered as a hindrance. A close relation between education and the environmental and cultural contexts as well as a judicious choice of research subjects from the prevailing reality, were also considered desirable.

31. The matter of availability of teachers was considered as a hurdle in both the introduction of science and technology in general education, and inducing the right attitude among the students. The whole problem is of course tied to the articulation between the higher and lower levels of education as well as to cost. The importance of creating a high degree of awareness of science and technology among the general public and the decision-makers was emphasized. It would contribute particularly for science and technology to have an impact on social life.

Item 5.4 -- Implications of the UNCSTD Conference for education in science and technology

32. With reference to this item, the following salient points emerged:

There must be a vigorous promotion of public understanding of science and technology so as to develop a positive attitude and awareness.

Developing this awareness is a difficult task, especially in developing countries. Therefore, the most efficient and adequate channels of communication appropriate to each country must be utilized to the maximum.

Science and technology should serve national development, as well as assist in the solution of social problems. Preferably, it should be endogenous in character.

Higher education can provide the quality of education needed through nurturing national talents of youth and serving as a basis for the development of other programmes of continuing lifelong education. It is imperative however to reduce the 'brain drain' through provision of working facilities, proper incentives and equality in opportunities for both sexes.

In serving national development and improving the social well-being of a people through the establishment of a new economic order, unpackaged technology must be made adaptable to local needs. Eventually, a country must develop its own technology and trained manpower.

33. The main conclusions of UNCSTD concerning self-reliance, human resources development, choice of technology, access to information, etc. are closely related to education. In this sense, the Vienna Programme of Action constitutes valuable resources for the development of science and technology education.

## STRATEGIES FOR THE IMPROVEMENT OF SCIENCE AND TECHNOLOGY EDUCATION IN RELATION TO DEVELOPMENT

### Item 6.1 The contribution of education to building up a favourable climate for the development and application of science and technology

34. The training of skilled manpower in science and technology for the different aspects of national development is considered a priority action area which must receive special attention in the light of local and national needs and realities. Science and technology are regarded as necessary prerequisites for sustaining the complex structure of modern civilization. If science and technology education is to be properly developed, an overall plan for the advancement of science and technology is also necessary. This is true particularly regarding manpower needs. But interaction between plans is such that adjustments will probably be necessary. The conduct of research in science and technology education is a necessary consequence of the need to plan.

35. Science provides a means whereby the individual can organize his or her own concepts and attitudes, classify experiences and communicate with others. Science can thus claim to make an important contribution to education as a whole, and have a place in the 'core' or central part of the curricula throughout the school system and non-formal education, and in the context and spirit of lifelong education. Thus science and technology education must be a part of general core curricula and be integrated with all education. A scientifically literate society is the aim of the final product.

36. Science education was considered to be an indispensable part of general education at all levels and for all target groups, especially for non-scientists such as politicians and administrative decision-makers, whose decisions and actions have direct relevance to the use and misuse of science and technology and its products, especially weapons. All citizens must be exposed to science and its processes in order to learn how to make intelligent decisions, based on an informed opinion. In brief, science teaching at all levels must change to emphasize reasoning, clear thinking, confidence and understanding. In addition, there is a question of relevance of what is to be taught. This must take into account socio-economic and cultural aspects of the community as well as the real problems of the environment. Further, to equip the student of today for the life of tomorrow, his science courses must include themes such as: energy; natural resources; population; resources of land, air and water; food and agriculture; health and disease; the place of technology in the economy, etc. Science and technology education should also be considered as an important element of preparing society for individual happiness and collective peace.

37. In the industrialized countries, science and technology, like language and arts, has become an integral part of the culture, and thus it has its distinct place for all in the spectrum of education. Science and technology is used as a means of competition at the national and international levels. This does not hold in the case of developing countries. The development of scientific attitudes on the part of society was considered fundamental for the development and application of science and technology in all countries and especially in developing countries. It was observed that primary education has been successful in achieving knowledge and the skill components of science education, but has failed to provide the learners with the needed scientific attitudes as a prerequisite for creating a favourable climate for development and application of science and technology. Attitudes are inculcated through social interaction, environmental contacts and modelling effects, and a real life environment is most effective for the development of attitudes. Scientific activities in school and outside of school are needed for desirable attitudes for development of science and technology.

38. At both primary and secondary stages as well as in non-formal education, the science teacher should encourage a student to think for himself and to rely on his own reasoning powers in devising solutions to problems which are real to him. Thus, the need is for self-reliance. This self-reliance does not come through rote memory of factual knowledge, but through experiencing what it is to be a scientist for the day.

39. In teaching science, both theory and practice should be emphasized. In this connection it is recommended that efforts should be made to expose secondary school children to industry through guided visits as well as involving industrial experts with the school. However, it will be necessary to overcome the problem of the lack of pedagogical qualifications of the industrial experts, and the resistance of the teachers to accept the intrusion of non-teachers in school affairs.

40. Syllabuses and textbooks should be revised in the light of the needs of the students and environmental realities. It is suggested that general guidelines for the methodology of curriculum reform should be drawn up internationally, but attempts should be made to produce textbooks locally. Imported textbooks ought to be well adapted to local contexts. And it is suggested that model examples for experiments that can be done cheaply, taking into account overcrowded classrooms and the low teacher/pupil ratio, be prepared.

41. Scientific methods involving processes such as the following should be emphasized in all the subjects taught, beginning at the earliest possible age:

observing;
classifying;
using numbers;
measuring;
communicating;
inferring;
using space/time relationships;
experimenting;
interpreting data;
controlling variables;
defining operationally;
formulating hypotheses and testing them experimentally;
formulating models and testing them.

42. The Vienna Programme of Action on science and technology for development, adopted by the United Nations Conference on Science and Technology for Development (Vienna, 1979), was discussed, and the Congress invites the Director-General of Unesco to send a copy of the report of this Congress to the United Nations and its specialized agencies, as well as to other focal points such as the U.N. Centre for Science and Technology for Development, national authorities, etc.

43. Over the years, education in particular science and technology education, has tended to be more and more mechanical. The ethic and aesthetic part is being lost. The mutual feeling for fellow human beings and co-operative efforts to improve their lot, or to show respect for their basic rights, are obviously on the decline. Instead, science and technology have led to the production of more instruments of war than to the comprehension and finding solutions to common problems of life. The reason and purpose of life must not be sacrificed in developing a socio-economic system based on science and technology.

A. Primary-school level

44. The diffentiation of 'science' and 'technology' at primary school level was considered unnecessary. The fundamental strategy at this level would be to develop a methodology for understanding nature. Science teaching at this level should emphasize learning by doing in such a way that it is useful and relevant to the pupils in their immediate environment. The aim would be to make it as natural to learn about science as to learn one's native language. In order to achieve this it is recommended that in the training of primary school teachers, Member States should give greater emphasis to science and technology.

45. Among the main arguments justifying the incorporation of science into the primary curricula, it was added that if science teaching does not begin early in primary school, students may lose interest in taking it up later and, as a result, the science talents of the society could easily be diluted. We live in a world of change. We cannot teach our children the knowledge of the next century; but through adequate and relevant science and technology education, we can possibly equip them for gathering this knowledge as and when required. They can thus be trained for anticipating changes and for influencing such changes.

46. The goals of science and technology at the primary school level were considered and it is suggested that the development of an inquiring mind and a scientific approach is perhaps the most important goal, as well as the promotion of an awareness of the usefulness of measurements and quantification (arithmetic) in science. In this connection, the goal is not to teach too much, but to teach how to learn.

47. The following were considered as some of the major constraints upon the development of science and technology education at the primary level:

(a) Lack of policies for science education in the context of overall educational policies in certain countries.
(b) Shortage of specialists and qualified teachers for teaching science and technology in primary schools in developing countries.
(c) Lack of sufficient budget for science and technology education.
(d) Overcrowdedness in classrooms mainly in developing countries.
(e) Lack of facilities and teaching materials
(f) Language problems
(g) Shortage of time allocation to science teaching
(h) Pupils' attitudes towards science and their aspirations
(i) Lack of family involvement

B. Secondary-school level

48. The main problems in the development of science and technology education at the secondary level were considered:

(a) Overcrowded classrooms in the developing countries as a result of expansion of secondary education

(b) Lack of practical work and too much emphasis on academic work.

(c) Lack of contact with the working world

(d) Lack of qualified teachers

(e) Poor background of students for learning science

(f) Lack of relevant local textbooks and the high cost of imported textbooks

(g) Lack of essential laboratory facilities

(h) Lack of family involvement

(i) In some cases the language chosen for the teaching

C. Higher education and training

49. The shortage of qualified scientists, engineers, technologists and intermediate technicians was discussed at length and the following aspects were isolated for discussion:

Brain drain;
Research in areas not relevant to the needs of the country.
The need for university extension services.
Balance between academic training and professional training for science teachers.

50. Brain drain from the developing countries to industrialized countries was discussed in depth and considered a major problem. It was recommended that graduate students should do part of their graduate work abroad and the rest in their home countries. It was recommended that universities in the industrialized countries should encourage research students to devote their attention to developmental problems relevant to their countries of origin. And that these students be encouraged to return to their countries. It was observed that there is also a brain drain from the science teaching profession to industry due to differentials in salary and social status.

51. If universities and other post-school institutions are to meet the challenge of today, they must alter their training programmes to emphasize the retraining of their graduates and play a more active role in extension programmes. Science teaching in universities should emphasize research; and a favourable research climate should be established. Regional and national publications on science and technology should be encouraged and supported by Member States.

52. The training of science teachers for secondary schools, and the question of specialist science teacher versus a science teacher with interdisciplinary training were considered. It was observed that whilst most of secondary-school teachers were trained in separate subjects like physics, chemistry, etc., the real need was for a 'science teacher' who will be able to teach integrated science as well as the social, economic and technological aspects of science, and who is able to do experiments with familiar things. The importance of in-service training was emphasized.

53. Two further points relating to university education were also stressed; (a) it was recommended that university teachers should receive some pedagogical training, (b) university teachers should have more contact with primary and secondary schools.

D. Promotion of public understanding of science and technology

54. Many of the profound changes in the social, economic and cultural structures of modern society have been brought about by the development of science and technology. These changes may be furthered as science and technology is advanced. The general public will suffer the consequences of these changes without having been

prepared to meet them. Furthermore, as scientific and technological knowledge increases and their application becomes multifaceted in affecting human life, it necessitates a continuous public understanding of the causes and effects of these changes, especially for making sound individual and/or collective decisions. It was observed that public understanding of science and technology has not been achieved satisfactorily even in developed countries. The need for necessary actions for such understanding in developing countries is even more urgent.

55. Five target groups among the general public were identified:

illiterate;
newly literate;
unskilled workers;
people with a general education but very little science;
people with a science background but needing extension and updating.

Public understanding of science ought to be achieved through different educational programmes and approaches.

56. For the illiterates, it was recommended that use of specially prepared films and radio programmes should be extended for the popularization and understanding of science and technology. The content of instructional materials used in literacy programmes should include elements and ideas from science and technology.

57. For the newly literates, the same recommendation as in the preceding paragraph applies, but this has to be supplemented with demonstration and extension work, using simple experiments and multi-media approach. Rural newspapers have a major role to play and their use should be extended. The content should be related to the preoccupation of every-day life, for example: farming practices, food, health and nutrition. However, it should be recognized that this is not easy because of some traditional practices and beliefs.

58. For the unskilled worker, it was recommended that he or she should undergo training organized by industry and adult education institutions in partnership.

59. For people with a general education, the better use of newspapers and mass media was recommended. This needs:

(a) the persuasion of sponsors to take a more favourable attitude towards science and technology;

(b) the training of journalists and producers of mass media which should include a component of science, because in this area journalists are serving as teachers for the general public.

60. For some people who have some scientific and/or technical background, two complementary approaches were identified:

first, short-term training programmes on the job or in existing educational institutions;

and secondly, through non-formal means such as popular science magazines, television programmes and public demonstration lectures; and for the younger age-groups, encouragement of scientific clubs, scientific camps, scientific competitions, museums of science and technology, etc. Science and technology associations at regional and national levels should be encouraged and supported by Member States.

61. On the dissemination of material on science and technology it was recommended that:

(a) Publishers of international scientific journals should be invited to accept articles from the less developed countries, which meet the journals' normal standards and have a local relevance.

(b) Regional and national publications on education in the areas of science and technology should be encouraged. Unesco is invited to assist in this venture.

(c) It was observed that the preparation and dissemination of unbiased, objective, factual information on problems and trends in science and technology education is a difficult task. In this connection, Unesco's support to international, regional and national scientific and professional associations, both governmental and non-governmental should be continued. Similarly Unesco's support for the international network of educational newsletters in various areas of science and technology should be continued.

Item 6.2 - Science and technology education in the perspective of development needs

A. Linking science and technology education with productive work and community development

62. The participants unanimously recognized the need to associate science and technology education with productive work, in order to prepare the rising generation to cope with the problems of the community and at the same time to foster positive attitudes to work.

63. In this context, the participants expressed the view that, in order to derive maximum educational advantage, these links could be established from primary school onwards by devising productive activities that could or should be fitted into students' timetables. Such activities could be based on items already covered in the school syllabus, allowance being made for the level of the pupils, i.e. their intellectual and physical capacities. Research, it was pointed out, constituted an important factor in introducing such linkage between the school and the world of work in a very flexible fashion, to take advantage of a broad range of possibilities. With regard to young people's attitude to work, the participants drew attention to the need to encourage team-work, so that, in an atmosphere of emulation, pupils could develop qualities that would be useful to them in their future working lives, such as a sense of responsibility and fellowship, while at the same time sharing in the feeling of being part of a joint effort or accomplishment.

64. On the question of the contribution of productive activities to the development of creativity, the participants stressed the need to introduce a research element into such activities, which should not, however, be detrimental to academic education. The development of logical thought was regarded as extremely important. The participants also considered that young people should be enabled to take part in creative scientific and technological activities by undertaking productive and creative work themselves.

65. The participants made a careful study of the part that non-formal scientific activities could play in bringing science and technology education and productive work closer together. In that connection, they suggested that such activities might be carried on through science and technology clubs, science workshops for the young, etc. Some of the activities could be regarded as leisure-time occupations, while others should be more practical in character, relating to everyday features of the pupils' lives, such as hygiene and health.

66. The participants took the view that linkage between science and technology education and the world of work could be effective only if the school, the family and the whole community all co-operated in sharing the responsibilities involved in the education and training of the young, which, ideally, should be accomplished by different, but complementary methods. The school, by opening its doors to the community, could not only enable pupils to meet craftsmen, artisans and so on in their working environment, but could also invite such workers into the school to impart their knowledge and skills to the pupils. It was recognized that the training of professionals should provide them with the ability to communicate their knowledge; it should include, in other words, elements of teaching. Enterprises could provide training at certain levels for schoolchildren. Conversely workers should also have an opportunity to undergo training and/or to take refresher training, periodically, in the sphere of science and technology education. With a view to securing interaction between such education and productive work, the participants also emphasized the need to take advantage of all the resources of living tradition by enlisting the effective participation of the entire community. They considered it essential that no member of the community should be excluded from such participation or from training and that, for that purpose, special attention should be paid to the disabled.

67. The participants considered that the programme for linking science and technology education with productive work should definitely be subject to evaluation, which should cover not only the knowledge, aptitudes and attitudes of the people concerned, but should also take account of socio-economic and cultural factors.

F. The environmental dimension

68. It is a fact that deterioration of the environment exists. Such deterioration is the outcome of the indiscriminate practices of exploitation, processing and utilization of natural resources and their products. Although not new, these practices have increased at such a rate that they have become a major problem. Every human activity implies an interaction of humanity and nature, and results in a change in the balance of the ecosystems. Fortunately, nature has the capacity of self-regeneration, that is, of overcoming the imbalances.

69. Experience shows that, due to the rapid evolution of science and technology, man is now able to transform his natural and built environments to a degree that may affect his own and others' well-being and rights, and even overwork the self-regenerative capacity of nature, resulting in pollution, littering, exhaustion of natural resources, disturbances in the biosphere, and other problems.

70. Today, humanity should direct its efforts to achieving the benefits of social and economic development and to improving the quality of life, taking into consideration the preservation of the environment and the intelligent exploitation, processing and utilization of its resources. Several strategies for reaching this goal have been identified:

(a) support the self-regenerative capacity of nature; (b) restrain undesirable practices; (c) create alternatives to natural resources and/or to their products; (d) propose exploitation, processing and utilization technologies and systems that have minimal consequences on the balance of the eco-system.

71. Environmental education, aimed at eliminating both ignorance and neglect, will facilitate the implementation of the above-mentioned strategies, and contribute to solving environmental problems, and to achieving a life more appropriate to human needs and to the aspirations of present and future generations.

72. Science and technology education was considered an exceptional medium to provide the necessary elements for informed decisions on environmental problems. However, no one of the natural sciences above will be able to provide all these elements; a harmonious combination of all of them would be required, in line with the target group, the level of education, and the realities of the community concerned.

73. It was agreed that science and technology education alone will not be a sufficient condition to producing the behavioural outcomes required to find solutions to environmental problems. Given the fact that environmental problems are, to a large extent, the result of the interaction of productive and consumptive choices and patterns of the population, and the functioning of natural systems, the contribution of social sciences, humanities and law to the elaboration of environmental education approaches, contents and methods appear as a necessary complement to the former. In other words, a truly multi-disciplinary approach will be needed at all levels and for all target groups.

74. Other necessary conditions to implementing environmental education were recognized. Not only science and technology teachers, but all educational personnel, as well as the public at large, should be aware of, and sensitive to, ecological imbalances; environmental education should be a part of curricula at all levels, and for all types of education, according to the characteristics of each country. In addition to scientific knowledge, environmental education should develop social attitudes and values towards adequate conservation and utilization of the environment; personal example and actual practices are effective methods for developing attitudes and values; direct involvement of target groups in the identification of problems, formulation of solutions and the implementation of projects to solve such problems contribute to the creation of a social climate favourable to appropriate management of the environment.

75. A number of opportunities and mechanisms for carrying out environmental education activities were suggested, among these were school and out-of-school education activities; development projects; specific sensitization campaigns; special commemoration days or weeks; field trips and ecological camps; social service programmes and specific action groups.

76. Although environmental problems are often of regional or even world-wide dimensions, environmental education should take into account local conditions and result in personal involvement in local problems. Any strategy to implement environmental education should first be directed towards decision makers, managers and educational personnel, and then move on to the student population and to the community as a whole.

77. It is recognized that, unless a number of conditions are fulfilled, implementation of environmental education into action may end in failure. First of all, it requires the common effort and responsibility of individuals, communities, enterprises and institutions, led by the political commitment of each government; secondly, national policies, laws and regulations, as well as specific projects, should support community action; and thirdly, proper research and evaluation should indicate corrective measures for the programmes undertaken.

78. Finally, both environmental education and further action face problems, some of which were identified. It is necessary to train adequate numbers of qualified teachers required at each level and for each type of education. A need is felt in this domain for research and experimentation. The same is applicable to curriculum design, development and implementation. Unless there exists a favourable social

climate, educators alone will not be able to do the work; environmental education has to be included in the curriculum, otherwise neither will teachers be compelled to teach, nor will students attend. Environmental education is to teach people to have regard for the quality of life of future generations, although they are not accustomed to thinking on a long-term basis. Environmental improvement usually contradicts present practices and involves considerable costs. Finally, due to their multi-causal factors, environmental problems are complex and difficult to explain, hence to understand, whereas a thorough understanding of them is a necessary condition to making rational decisions on their behalf.

79. International assistance and regional co-operation, adapted to the characteristics of each country, are needed to cope with the demands of environmental education and further improvement of the eco-systems.

C. Cultural aspects

80. Science and technology are an integral part of modern culture. Therefore, in the design of successful science and technology education programmes, consideration should be given to local cultural patterns and values in order to make such programmes acceptable and understandable to the community.

81. It should be clearly stated that scientists and other professionals involved in science and technology, whether it be in the education or application thereof, should not underestimate current local practices. Old and traditional practices are not necessarily bad or inefficient. As a sound approach, an inventory of these practices should be made, identification of advantages and disadvantages, particularly regarding needed inputs, and alternative solutions worked out and tested. In this way, local practices can be improved and science and technology adapted and built on existing conditions.

82. The same policy should be applied to the use of local human resources. Existing practitioners should be involved in environmental education as well as in project activities. Training should start on the level and utilization of techniques already present in order, not only to improve the present stock, but to culturally enrich new techniques and practices.

83. Legitimation is an important condition for science and technology to be accepted. The sources of local power to support a project have to be identified and consulted, and their advice taken into consideration. In general, a favourable attitude is required to successfully implement science and technology education.

84. As far as recruitment and training of change agents, including teachers, are concerned, experience shows that those coming from project areas are more culturally fit and therefore stay longer and are more efficient. On the other hand, those coming from other cultural regions have difficulties in adapting themselves to the new context and in understanding the other's problems.

85. The rate of development and expansion of science and technology education in a given culture is controlled or facilitated by the scientific and technological tradition of that society. If the process has to be accelerated, the whole population concerned should be involved. In the long run, a good school programme of science and technology will permeate the total culture and create the appropriate climate.

86. Science and technology education should be designed to encourage women to participate in national development. Special means should be provided to enable women to re-enter their former scientific or technological profession if their family responsibilities have made it necessary for them to leave for a while.

87. It is recognized that some local languages lack the necessary vocabulary for transmission of scientific and technical knowledge. This situation creates a dilemma: whether to use a foreign language or to enrich the local one. In the long term, the latter seems to be the advisable approach to developing the understanding of the population at large with regard to science and technology.

88. Finally, in those countries where teaching of science and technology, particularly at primary level, becomes difficult, language can be used to give a "scientific and technological" character to the culture. In these cases, language is used first to explain scientific and technological phenomena, structures and processes, and secondly to introduce, in most of the verbal and written messages, a scientific and technological bias. In this way, every textbook, for example, can convey messages with scientific and technological flavour that progressively will build up a scientific and technological awareness in the society.

D. Social relevance

89. The participants acknowledged that science and technology should be fully incorporated into education at all levels, and in both formal and non-formal systems. Some speakers pointed out that efforts in that field should bear primarily on two fundamental elements -- curricula and teacher training.

90. Curricula should cater for the needs of the environment and reflect the concerns of the community. What is taught should relate to the real problems of the environment and have an impact on people's daily lives. To that end, and, according to the level and characteristics of the type of study involved and the needs of the different social groups, environmental education might be designed to provide science-based knowledge and to develop behaviour patterns and values conducive to the solution of environmental problems.

91. The importance of an interdisciplinary approach was emphasized as being essential both in education as a whole, and in the teaching of science and technology in particular which, they stressed, should be linked with the teaching of the social sciences and humanities. It was pointed out, for example, that language was an important and decisive element in science and technology teaching and in the all-round development of the pupils' personalities. For that reason, stress was also placed on the importance of preparing adequate teaching materials, including textbooks whose content should enable children to identify themselves with their environment and to do something to improve it. The achievements of science are a universal asset, and, with that in mind, scientific and technological associations should be encouraged to help in designing school textbooks and curricula. Research should be undertaken to find out how children might react to science and technology.

92. Attempts to match science and technology to the pressing everyday concerns of the public should not result in alienation from their own environment, and a greater awareness of the world at large should also be sought. From that point of view, the teaching of science and technology, as a part of environmental education, might help to impart a deeper knowledge of eco-systems, and of the potential impact of human activities on them, since the link between environmental education and science and technology education was identical to that between the environment as a whole -- i.e., both its natural and its man-made components -- and science and technology.

93. Action should be taken to provide opportunities for parents to find out about their children's activities in the field of science and technology education, so as to help them to support the learning process actively.

94. In relation to science and technology education, specific attention should be paid to the existing problem of "brain drain". It was agreed that students should be trained, as far as possible, in and about their national environment, the challenges of development and the contributions they can make to meet these challenges.

95. From the discussion of science and technology education in the perspective of development needs, the following suggestions emerged:

(a) In view of the great importance of science and technology education for national development, its improvement and strengthening should be considered as one of the priority tasks in national development programmes. More attention should be paid to such problems, as training and retraining of science teachers, modernization of science curricula, use of mass media, development and use of new science teaching-learning materials, consideration of different types of science and technology education, including in-school, out-of-school, adults, etc., and the development of national institutions and facilities.

(b) More research and experimentation and evaluation are required in the field of science and technology education in order to develop and test new and effective approaches in this domain.

(c) The linking of science and technology education with productive work should be encouraged at all levels of education, in order to stimulate the creativity of students to develop skills and a favourable attitude to productive work, as well as to ensure effective application of knowledge to the needs of society.

(d) Science and technology education should be designed to encourage women to participate in national development. Special means should be provided to enable women to re-enter their former scientific or technological professions if their family responsibilities have made it necessary for them to leave for a while.

(e) The development of science and technology education should be of the endogenous nature, based on cultural traditions, heritage and national resources, including national languages, and fully utilizing the achievements in science and technology.

(f) A multidisciplinary approach in the development of science and technology courses and curricula would offer a more comprehensive view of the unity of nature and of the place and role of man in his environment. This approach should be focused on societal needs and problems.

(g) Considering that, at the present time, education could and should contribute to the solution of the problem of contemporary environment, and that, in this perspective, science and technology education would help to generate a deeper knowledge of the ecosystems and the impacts on them of human activities, it is suggested:

  (i) to introduce, on the basis of an interdisciplinary approach, the environmental dimension into education in general, and particularly in the group of disciplines covered by science and technology education, and to include a basic introduction to, and evaluation of the relation between life-styles and environmental quality, locally, nationally and globally;

(ii) that curricula of modern systems of education must include aims and content related to the environment, and that education must be associated with the environment;

(iii) that environmental education and its methodology, based on the nature of the environment, is destined, among other things, to establish an irreversible interest in environmental issues, and is more than the sum of the learning components of science and technology because its ultimate aims are overtly effective and are directed towards influencing behaviour.

Item 6.3 DEVELOPMENT OF CONTENT, METHOD AND MATERIALS FOR SCIENCE AND TECHNOLOGY EDUCATION

96. Educational content in science and technology education covers all the elements of skills, knowledge, know-how, attitudes, values and patterns of behaviour transmitted to, and acquired by, the learner through formal and non-formal educational activities in this field. The acquisition of the content of science and technology education is a lifelong process, and it should be encouraged from the earliest educational level. Science and technology education, when viewed as a vital means to achieve national socio-economic and developmental objectives, raises the question of its relevance to such objectives. The attempt to adapt science and technology education to national, social and developmental needs and to the cultural traditions of the country is essential. With increasing awareness of the practical applications of scientific and technological knowledge, it is also necessary to link the content of science and technology education with what takes place in everyday life, particularly the natural and technological environment. The curriculum, which defines the content of science and technology education, must be developed and supported by many agents who either participate in its development or influence it. Such agents include parents, the community members, industry, the scientific community, teachers, etc. In the process of developing curricula, various learners' characteristics, such as his/her readiness, interest and motivations should also be taken into account, and further, "what to be taught" or "what to be learned" should closely correspond to the requirements and conditions of the developmental stages of the learner.

97. Though it requires much time and energy, maximum efforts should be made in constantly updating basic science courses to keep up with the development, discoveries and acceleration of scientific knowledge or concepts, and with the changing socio-economic reality. One participant suggested a universal syllabus for science teaching. However, the majority of the participants felt that this would be impractical, yet some recognized the possibility of identifying a core syllabus. But the group agreed that the curricula should be developed on the basis of the specific needs of the society. Updating curricula inevitably requires reorientation or reinforcement of pre-service and in-service teacher-training programmes, and improved and efficient diffusion or dissemination mechanisms whereby new scientific knowledge or discoveries can be incorporated into science education courses with a minimum time lag. A variety of assessment techniques to evaluate the quality of curricula is also demanded, and such techniques should be devised constantly to receive feedback on the effectiveness of the curricula from various users or agents such as the learner, the teacher, teacher trainers, school administrators, industry and policy-makers.

98. Science and technology education has to be accepted and fully supported by the general public in the community. The importance and practical nature of science and technology education must be conveyed and popularized to the public. The

use of various mass media, such as radio, television, magazines and newspapers may be very effective for this purpose. Also, the availability of recurrent or out-of-school educational opportunities determine the magnitude of success in this enterprise. Science museums and centres for science and technology education have an important part to play in the promotion of understanding and appreciation of science and technology by the general public. They should be supported, and developing countries should be encouraged to develop activities appropriate to their own needs.

99. With the increasing awareness of the importance of the learning process, more learner-oriented or inquiry-oriented teaching methods are receiving much attention. Teaching methods or instructional systems, which enable the learner to engage himself in creative or divergent thinking, problem-solving and self-learning, and to explore the new avenues of communication, productive work and technological innovation, through such methods as simulation games, project work, should be promoted. Closer attention should be paid to the learner's participation in experimental and practical activities, and teaching methods must be flexible and more adaptable for the learner to anticipate a changing future and to make the learner feel that he/she can influence its direction and have control over it.

100. Teaching methods in science and technology education must be designed to close the gap between theory and practical work. There is a need to establish close, linkage between scientific research and practice. New teaching methods and training programmes which encourage research utilization or an application process in solving pertinent and practical problems could be promoted. The modalities of establishing efficient dissemination mechanisms to diffuse scientific knowledge to science and technology educators, and of providing communication opportunities or channels between science researchers, science technology educators, and administrators and policy-makers, can be further explored.

101. More utilization of the media, printed and audio-visual teaching materials, should be encouraged as well as active utilization of locally available material resources. It is both an economic and a pedagogic advantage to produce low-cost materials or equipment for science and technology teaching, since the dimensions and quantity of science and technology education will be expanded and the number of people who participate in education will increase.

102. With a more active and participatory learning style of the learner in the classroom, the teacher-student relationship needs to be re-evaluated. What kind of direction or guidance can the teacher provide to the student? In what manner can the teacher assist the student without interfering negatively with his learning? The interactive processes, involving such variables as the nature of the task, the types of instructional aids or materials, motivational levels, readiness for the task, personalities, attitudes of the learner and teachers' teaching styles and personalities, could be further explored to establish appropriate teacher-student interaction.

103. If science and technology education is to contribute actively to the achievement of relevant national objectives and to the solutions of various socio-economic and technological problems, it naturally calls upon the mobilized and cooperative efforts of several disciplines. No single discipline itself, for example, can sufficiently or effectively tackle complex environmental problems which cover water, energy, climate, food, etc.

104. Integrated science teaching has to consider different levels, for which varying processes or qualities of integration may be required. At the primary school level, science courses in many countries are well integrated. At the secondary level,

where various natural science subjects are taught, integration, although valuable, should be taken in stages. There is need at this level to explore further and to clarify the concepts, criteria and the degree of integration of different science subject-matter. With the increased degree of sophistication of integrated science teaching at this level, there is a need for reorientation or reinforcement of training programmes for teachers and teacher-educators. Although science structures are more unified than in the past, at the level of higher education, there is a tendency to further diversification or specialization of science.

105. It has been pointed out that technology derives both from the application of scientific knowledge to practical purposes and as a response to practical problems. It was suggested that technology practice could provide a framework for integration.

106. An active interdisciplinary approach among several natural science disciplines has already been observed in such scientific research areas as molecular biology, geophysics, biochemistry and astrophysics. Traditionally divided domains within the subject become unified. For example, biology treats botany and zoology together.

107. However, especially at a higher level of education, integration of various scientific disciplines faces difficulties. In any case, even if a full integration of a certain science is difficult to achieve, it can offer some basic theories or principles to other disciplines for mutually beneficial purposes without losing its identity. For example, efforts could be made to coordinate the teaching of mathematics, science and technology-based subjects. In order to promote such coordination or working relationship between subject disciplines, the following points have been suggested:

(a) Pre-service and in-service training programmes should be designed in ways that encourage an interdisciplinary approach to subject teaching.

(b) Curriculum development groups should contain a cross-section of subject expertise.

(c) Maximum cooperation should be sought within the school system in order to achieve close coordination on appropriate combinations of related topics in science, mathematics and technology-based subjects.

## A. TECHNOLOGY EDUCATION -- ITS DEVELOPMENT AND LINK WITH SCIENCE EDUCATION

108. In defining the scope and content of technology education, care has to be taken to avoid both the terminological confusion resulting from a multitude of names for skill-oriented education at different levels and also the distinctions made between 'education' and 'training' as well as between 'general' and 'vocational or technical' education. In the current interaction between synthetic tendencies in education, which seek the unification of basic concepts, and the analytical tendencies of evolving towards further specialization, the integration of knowledge and skills, as well as attitudes and values contributes to the development of a concept of technology education, which is broad-based and relevant to national socio-economic development needs. In such a concept, the total process of education, as its fundamental objective, aims at enabling the student to understand his three-fold environment of nature, society and man-made systems in an indivisible combination of science, that deals with natural phenomena, with social sciences, that explore society and with technology education, that provides an introduction to man's application of his scientific discoveries and inventions in the solution of problems he encounters in his progress.

109. Not only should technology education be provided at all levels of education as an integral element of the curriculum, but the contents should be so determined as to make the knowledge, skills and attitudes provided by it relevant to the needs of each society. As in respect of other types of education, the curriculum must grow from an analysis of problems and needs, and should assign high priority to the development of problem-solving ability. It has to be emphasized that skills to solve the immediate problems are of little use unless further strengthened by a capacity to adapt to future needs in a rapidly changing world. Hence the importance of maintaining a balance between scientific knowledge and scientific modes of thought, on the one hand, and skill training on the other. But, in the determination of the technological systems out of which the content is drawn for technology education, equal consideration must be given to traditional and rural technologies, usually found in developing countries, as to those evolved in industrialized countries.

110. Technology, as a means to extend man's biological capabilities, is universal. Hence technology education is a sine qua non, both to understand the scientific basis of techniques and devices, and also to acquire the requisite skills for productive work and efficient living in different societies. Not only should all persons be equipped with a measure of scientific and technological literacy for meaningful life in a continually evolving society, but the non-technologists, engaged in policy- and decision-making at different levels need to be inducted to technology to ensure more effective functioning, whether as legislators, administrators or planners. Scientists and educators are as much in need of technology, since they are interested in the advancement, storage and dissemination of knowledge, processes pertaining to the field of informatics, a branch of technology. A case exists for introducing a significant element of technology in the general education curriculum at all levels. A particular point to be borne in mind is that a vast majority of children terminate their schooling at the primary and lower secondary level, and their only chance to be inducted to technology education is at these levels. The large concept of technology could be suitably presented, at each level, as an historical evolutionary process to show how man, in each society, developed his techniques and tools.

111. Two main considerations relate to the development of technology education. The first concerns the teachers. Not only should competent persons be attracted from lucrative careers in industry to the teaching profession, with better conditions of service, but they need to be given requisite training and orientation specially to overcome the difficulties of a social nature resulting from the importance attached to academic education as opposed to practical, skill-oriented training. The other consideration relates to methods, materials and equipment. With attitudinal change as a basic objective of technology education, both for future technologists and the non-technologists, innovative approaches to teaching and learning need to be encouraged.

112. As regards materials and equipment, a special word of caution needs to be sounded in respect of developing countries. Besides being unable to afford the cost of sophisticated material and equipment developed in industrialized countries, the devloping world may find some of such material and equipment unsuitable, or irrelevant to the prevailing level of technological development. Some countries will continue to need assistance for producing locally as well as importing, when feasible and appropriate, the requisite teaching materials and equipment for technology education. It would be appropriate to consider setting up a fund for this purpose with the assistance of industrialized Member States.

## B. DEVELOPMENT OF MATHEMATICS PROGRAMMES - THEIR LINK WITH THOSE IN SCIENCE AND TECHNOLOGY

113. Through its increasing use as a tool and a language for the scientific treatment of situations, mathematics today pervades the whole of human experience.

The demands for mathematical skills are therefore on the increase. However, mathematics cannot be regarded only as the mere tool of scientists, engineers and technologists of all kinds. It corresponds to a very general human experience, not necessarily subject to verification against natural phenomena, an experience in which reasoning is paramount. It deals with symbols and with models, which may be chosen as suitable for analysing increasingly varied situations, including individual behaviour, and the attitude and trends in opinion within society as a whole. It also makes use of techniques such as graphs, tables, models, algorithms and diagrams, which provide extremely powerful and rich means of conveying information not necessarily linked with the environment.

114. As a characteristic human experience, mathematics is not to be solely identified with the practical use it can be put to. Its teaching is not to be linked uniquely with the application it may have in the physical environment. In fact, the interest and concern of the learner in mathematics may go beyond what is of practical use to him. His mathematical activity may assist, in a deep sense, in his development. It is relevant here to stress how much mathematics has contributed to civilization and to the development of the human mind.

115. Mathematics education enjoys an important time allocation at school. It starts at an earlier age than science education in the primary curriculum.

116. Some basic mathematical skills are needed by people in the context of their private life as in that of their working life. They may also be necessary in the wider contexts of the social, economic and political life of the country of which they are citizens. The implications for mathematical education are that it should be able to cater for these triple needs. However, no fundamental difference exists between the nature of the mathematical education required for daily life, for its use at the place of work and for taking an intelligent part in the social, economic and political life of the community and the nation.

117. The link to be established between mathematical programmes and science and technology programmes is not to be regarded as an integration, except perhaps at the early stages of schooling. In fact such an attempt would be erroneous. What is needed is for the two to reinforce each other in the way, for example, in which mathematics becomes functional, and finds applications in problem-solving in science and technology, and the latter makes use of the mathematical formalisms to build up its theories.

118. Mathematics education should provide training in 'problem-solving'. However, the technique involved in this activity may be rather superficial, and may not necessarily enable the student to apply this skill in actual life. It would be more advantageous if training was given in the identification of problems, their formulation in mathematical terms and their resolution by selecting, and applying the appropriate mathematical formalism.

119. The teaching of mathematics should adopt project work, and activities involving the use of teaching aids which need not be sophisticated. Cooperation should be encouraged between methods used in mathematics and science. For instance, the ripple tank may be used in teaching certain mathematical curves. The use of textbooks is not to be ruled out since it provides the teacher with an important means, among others, of developing the required skills in the student.

120. The criticisms of certain new approaches in 'modern mathematics' has been due, not only to the use of abstract concepts unsuited to the level of maturity of the young, but also, in part, to the insufficient training given to teachers and adults in the society, and to the lack of close correlation with the developmental needs of the country.

C. DEVELOPMENT OF INFORMATICS PROGRAMMES

121. The general feeling is that elementary informatics should not be taught as an autonomous discipline. It should rather be effectively introduced into other disciplines as a relevant and up-to-date technological application with great potential.

122. In most countries, however, micro-computers are not yet available, although the price of the hardware (computers and their input/output facilities) is falling continuously. In those countries where the 'hardware' is already available, there is still the major difficulty about the 'software' (programmes for the computer), which is expensive to prepare, since it requires a degree of specificity, relating it to the people and environment for which it is meant.

123. The experience of countries which have already introduced informatics in schools suggests that it is an effective means of:

(a) demystifying the computer and other electronic media; and

(b) promoting self-learning, with the proper guidance of the teacher, who should be able periodically to evaluate the effectiveness of the learning.

124. However, it may be remembered that computer logic is rudimentary. There may be a real danger that the indiscriminate use of the computer at the school level may generate in children mere simple yes/no logic.

125. Although such an introduction would be premature in the school system of developing countries at the primary- and lower-secondary levels, it does not follow that the upper-secondary and university levels should not introduce informatics programmes. At the upper-secondary level an introduction to informatics would have the advantage of familiarizing with the computer and with microprocessor techniques. There was agreement that universities should have the programmes and the equipment.

126. In this context, in view of the inevitable eventual introduction of the hardware in developing countries, it is suggested that Unesco should play a role in promoting pilot projects in such countries and assisting in preparing 'software' that would help those countries to introduce those devices in ways most helpful to their needs.

D. NON-FORMAL AND OUT-OF-SCHOOL PROGRAMMES IN SCIENCE AND TECHNOLOGY EDUCATION

127. The importance of non-formal and out-of-school programmes in science and technology is borne out by the fact that they serve a wide variety of educational objectives pertaining to a varied clientele, which includes schoolchildren, through enrichment activities which supplement school activities by updating curricula according to new discoveries, inventions or events; early school-leavers and dropouts, in remedying their gaps in scientific and technological knowledge and skills; special professional groups, particularly in the rural areas, in providing them with scientific and technological information specific to their occupational needs; the general public, in promoting the understanding of scientific and technological developments and thus ensuring changes in attitude beneficial to development; and the scientists themselves, in enabling them to be informed of areas of science and technology outside their own fields of specialization. To satisfy such diverse needs and objectives, careful planning is necessary

including a survey of the scientific and technological information needs of the various groups and the selection of a strategy in accord with the available resources. Structures and modalities for programmes for such a range of beneficiaries and objectives have to be diverse, and should utilize all available facilities in the community. The school will be an obvious centre on account of its many facilities, which are generally used for only a fraction of the day. Other institutional facilities would include museums (especially when they are activity-oriented and not merely places for display of exhibits), laboratories and industrial and agricultural enterprises.

128. The mass media -- in particular the printed media, such as newspapers, magazines, and books, as well as television and radio -- have a key role in the promotion of scientific and technological literacy. In rural areas, it may be necessary to use mobile teams and units for this purpose. These, and other forms of distance education, are important in improving the possibilities of teacher training and retraining. But it is not within the capacity of all communities to produce the material and the software for the media, even though the book would continue to be an effective instrument. Hence the need exists for information on the availability of suitable materials and software, and for facilities for their dissemination, adaptation and, where necessary, translation into national languages. It is suggested that clearing house services in this respect are urgently needed.

129. While teachers, when available and motivated, could make a distinct contribution, the mobilization of other personnel must be pursued as a matter of priority. Among the people who can thus be useful we may include the scientists themselves, who must not only be made responsible for informing the general public of scientific and technological developments, but also trained to perform this function effectively; experienced persons, no longer in active service, but with the requisite academic and practical background; practitioners of development activities in agriculture, industry, transport, etc., and scientific and technological associations. In view of the number of ministries, agencies and organizations that usually handle non-formal and out-of-school educational programmes, coordinating mechanisms and a definite policy and strategy are essential to ensure effective action. It is also important to establish operational linkages between formal and non-formal education in science and technology.

Item 6.4 -- <u>Promotion of the endogenous development of science and technology education</u>

130. The initial discussion focused on two parts of the working paper. For the first part, speakers exchanged views on the meanings of the phrase 'promotion of endogenous development'. Subsequent discussion was devoted to the five sub-sections which follow. It was explained that the word 'endogenous' refers to development from within a country. The principle of endogenous development requires research on ways of thinking and learning in different cultures. Questions were raised concerning who should promote such development and whether endogenous development implied development only from within a country. In the case of science and technology education, it was agreed that, although science itself is universal in nature, educational development should be based on national priorities and should be relevant to local situations. Such endogenous development does not preclude the exchange of ideas and experiences, however, either within a country or on an international basis. In addition, the danger of curricula -- even endogenously developed curricula -- being imposed on teachers and schools within a country, was emphasized. Participants agreed to accept the analysis of the concept 'endogenous' suggested in the working paper and to proceed in a discussion of its five sub-sections.

A. National infrastructures for policy and planning

131. Many participants focused on important factors affecting the science curriculum, including the following: the need to develop science endogenously, and the psychological blocks to such development; the structure of the school and its implications for the curriculum (e.g. separate classrooms for each subject); the language of instruction (especially the potential for using local languages for science teaching and the implications of this for the development of scientific terminology); the effects of examinations (especially alternative ways for their development); and the difficulty (or perceived difficulty) of learning mathematical and scientific concepts. It was also emphasized that science and technology education should be closely linked with the social context.

132. The discussion also concerned the structures used to develop and implement the curriculum. The need for balance in curriculum deliberation among all concerned groups and a particular kind of forum required to promote this balance was suggested. It was also pointed out that good planning requires attention to the problems of implementation so that earlier failures are not repeated. In this respect the key role of the teachers was stressed and the problems of remote rural areas. The possibility of using local human resources such as farmers and elders of a village to participate in the educational effort was also suggested.

133. The discussion concluded with a brief reference to the usefulness of work experience as part of a student's formal education and of informal means of education, both of which can help him/her relate science better to the world of work.

134. The implications of the demographic explosion and economic recession were introduced as factors affecting both endogenous development and the science and technology education appropriate to such development.

135. Informal (i.e. out-of-school) education was also pointed out to be an important means of influencing public attitudes towards science and technology. Co-operation between agencies having different, but complementary roles was stressed.

136. The following suggestions were made:

(a) The principle of endogenous development is affirmed, and is particularly encouraged in the case of curriculum development for science and technology education. Such education should support the scientific and technological development of the country, discourage environmental destruction and wasteful consumption and respect national heritage and cultural diversity.

(b) The adaptation and modification, at the local level, of curricula developed nationally should be encouraged in order to ensure their relevance to local needs, opportunities and resources.

(c) Structure or networks should be developed in all countries to facilitate the deliberation of educational policies by all concerned groups in order to promote an appropriate balance in the resulting plans and programmes.

(d) It is important to draw attention to the part that women can play in creating an atmosphere conducive to the development of science and technology. To enable women to play such a part, it would be helpful to:

(i) stress the establishment of schools to provide science and technology education for girls where the system is not co-educational;

(ii) lay emphasis on the possibility of including elementary science and technology education in the non-formal education available to girls and women who have not attended school.

(e) Priorities in science and technology education should be continually reviewed in the light of technological development and the changing needs of society.

(f) Each state should establish a national mechanism to co-ordinate the planning of science and technology education. To facilitate this planning, effective relationships should be maintained among institutions such as the following:

(i) the development-planning organization;
(ii) investment and financing institutions;
(iii) R & D institutions;
(iv) the education and training system;
(v) public and private undertakings;
(vi) the industrial property set-up, technical information services and patent information services;
(vii) standard-setting and quality-control systems;
(viii) legal systems.

B. Research and evaluation

137. Many speakers expressed concern that research in science education should be applicable to the practical needs of teachers and students, schools and educational systems. More specific ways in which this might happen include: more research into effective teaching and learning processes; better dissemination of research results; additional centres for research should be located in developing countries or regions; greater participation in research activities by teachers (action research).

138. The different contributions to be made by 'experimental' and 'naturalistic' research provoked a variety of comments. An overemphasis on statistical methods was shown to have its own methodological problems. The caution that naturalistic studies could be inappropriately seen as a panacea for all educational problems was also noted. The contributions of two different types of knowledge (theoretical and practical) should be recognized for maximum benefits from research to be realized.

139. The value of surveys to describe the context of development, including an inventory of national resources was also suggested as being valuable. The exchange of experiences between countries was also felt to be valuable. For example, experiences in both African and Arab countries, in which curricular experiments had been adapted to different contexts, and the reasons for their relative success or failure, were discussed.

140. Evaluation methods, both for students and curricula, should be continually reviewed in the light of educational changes. Evaluation should assess the extent to which the goals of science and technology education are achieved, including those involving skills and attitudes.

141. Both the processes and products of research should be explained clearly and should be accessible to all involved in science and technology education. Science teachers should be encouraged and taught to assess the outcome of their own curricula and to share their findings with their colleagues at teachers' conferences and workshops, and in as many other ways as possible. The importance of maintaining a high level of quality among teachers was also stressed.

142. Concern was expressed about the split between research and teaching at university level, where teachers are selected and promoted on the basis of their research competency, but having little regard to their teaching ability.

143. The following suggestions were made:

(a) Science and technology education research studies should include more relevant naturalistic studies, as well as experimental studies, on how science teachers can be better trained, and students be better taught in support of endogenous development. The results of such studies should be better summarized, interpreted and disseminated for the use of classroom teachers. Research results should be used as an input in the endogenous development and modification of curricula.

(b) In addition to such systematic research on science education, attention should be given to pragmatic experiments conducted directly by teaching institutions and teachers for the purpose of adapting the content of their curricula or improving the efficiency of their teaching.

(c) Regional clearinghouses for science and technology curriculum materials, research reports and evaluation instruments, published in the language of the region, should be established. Publication of journals in the local language should be encouraged. These are to convey to science teachers, ideas and instructional hints, based on research findings, classroom practice, etc.

(d) In the area of evaluation, there should be a continuous activity of evaluation of curricula, after their experimentation in the classrooms, in relation to the objectives defined at the national and local levels.

C. <u>The training of science and technology education personnel, including retraining</u>.

144. It was agreed that, since teachers are the key to the successful development and implementation of new programmes in science and technology education, the education and training of teachers is of crucial importance. The structure and mechanism of teacher-training should reflect local needs and conditions.

145. In relation to the provision of appropriate teacher education, it was suggested that the training of teachers ought to be much broader in scope if they are to be successful teachers of, say integrated science or science-in-society courses. It was also suggested that preparation for such teachers requires additional research.

146. In the case of university teachers themselves, the need for training for their teaching responsibilities was emphasized by many speakers. The experience of several countries is that workshops or courses in this area are already required of new university teachers.

147. It was suggested that endogenous development can be stimulated by the training of high-level specialists through establishing post-graduate programmes in science and technology. This would reduce the number of students who must learn scientific research in other countries, and also reduce the 'brain drain'.

148. The following suggestions were made:

(a) In recognition of the importance of problem-solving as a goal for science and technology education, a more concerted effort should be made to give teachers and students training in the solving of problems

actually existing in their own lives and environments, so as to reinforce the relevance of science.

(b) University departments of education and teacher-training colleges should be encouraged to broaden the scope of science courses offered to teacher trainees and, where appropriate, offer courses in integrated science and environmental science. Other courses should be developed in those technical fields where there is a serious shortage of manpower.

(c) It seems desirable that those recruited as university lecturers should possess ability in teaching, in addition to their scientific expertise.

D. Centres for the improvement of science and technology education, curriculum, equipment, training, documentation, etc.

149. Centres have been found useful for several purposes, each of which can contribute to endogenous development of science and technology education. These purposes include: curriculum design; development of materials (including print materials and equipment); documentation; and in-service teacher training.

150. Teachers should participate in curriculum development. While 'reinvention of the wheel' is undesirable and wasteful of energy, it was agreed that the curriculum development process must stress national and local needs. Materials developed elsewhere should be adapted for local use.

151. The computer was recognized as likely to become of great value in the future. At the same time, it was noted that, as yet, traditional methods of documentation have often been inadequately used.

152. The following suggestions were made:

(a) In view of the shortage (in many countries) of qualified science technicians and laboratory assistants for industry and for universities, colleges and schools, studies should be undertaken to identify specific needs and to recommend and implement appropriate training programmes.

(b) Associations, societies and training centres can contribute to the endogenous development of science and technology education in a number of ways, including:

(i) publishing material relating to the teaching of science and technology;

(ii) organizing seminars or symposia in response to specific problems;

(iii) assisting the local development of teaching material in science and technology subjects;

(c) Emphasis should be placed on the need:

(i) to set up or strengthen national structures for the local production of equipment for use in science and technology education, for example, teaching equipment centres, or the production of their own equipment by some technical schools, etc.

(ii) to call attention to the judicious use of means already available. For that purpose, emphasis should be placed on the importance of having the technicians essential for the use, maintenance and repair of scientific and technological equipment at all levels (schools, universities, etc.), and for efficient organization to ensure better use of heavy equipment (such as the pooling of equipment).

(d) For further suggestions on this topic, see also paragraphs 191 and 192.

E. Professional organizations for the development of science and technology education.

153. The need for a variety of structures and organizations to promote science and technology education was recognized. A particular suggestion concerned the need for international funding to support science and technology education associations in developing countries committed to endogenous development. It was pointed out that, in some countries, such associations do not exist at present, despite their importance.

154. One particular need was noted for organizations devoted specifically to the deliberation of science curriculum policies. Such organizations, it was suggested, require the co-operation of all interested groups who could develop authoritative recommendations for governments. It was pointed out that such organizations should encompass not only educators, but also various involved sectors such as the business community.

155. It was suggested that in the interests of improved mutual understanding and co-operation, science teachers and research scientists are urged to collaborate more closely. Possible mechanisms to stimulate such collaboration include:

(a) teachers joining scientific associations;

(b) scientific associations forming education sections; and

(c) governments and other agencies taking steps to faciliate co-operation.

INTERNATIONAL CO-OPERATION

Items 7.1 and 7.2 -- Main issues and objectives of international co-operation in science and technology education, and main areas and methods of international co-operation in this field

156. International co-operation is seen as an important element of optimizing the use of the resources that each country individually possesses. Naturally, it should not conflict with endogenous development which, of necessity, is based on perception by each country of its own reality. Thus, the criteria for international co-operation were considered as stemming from the distinction between what is common to a given group of countries and what is specific to each one of them. Certain objectives of scientific and technological education are shared by a considerable number of countries. This is the case with the general structure of the education systems and the progression through them, the tendency towards project-oriented education, the coexistence of a discipline approach for the basic sciences and interdisciplinarity when dealing with concrete problems and natural systems, etc. But the social, economic and cultural contexts are as proper to each country as are their developmental aims, financial constraints, the need for innovation and the background preparation of the students.

157. Although international co-operation lends itself to whatever is common to a group of countries, thus implying a certain degree of similarity between them, this does not exclude the possibility that certain developed countries can also contribute the experience they have accumulated in relation to certain problems of interest to less developed countries, thereby narrowing the scientific and technological gap between the two.

158. Areas of commonality of objectives, as mentioned above, should serve as fertile ground for international co-operation at the regional level through the exchange of experiences and expertise in teacher training, development of appropriate educational materials, exchange of personnel and the dissemination of professional information. All international co-operation must be backed by an appropriate national approach to education as a nationwide system involving, not only the Ministry of Education, but also industry, agriculture, etc.

159. Brain drain is normally considered as a negative element in the development of science and technology education in the country suffering from the drain. In addition to whatever international co-operation can do to reduce brain drain, an aspect which could be labelled 'intellectual drain' was considered to be equally important. This refers to the concentration of researchers on problems of international relevance rather than on local or national problems, the aim being publication, and the building up of a reputation, disregarding, at times, the context in which they develop their activities. Collecting national experiences of this problem would constitute an important contribution to its solution. These case-studies could help in designing educational processes that sensitize people towards the problems proper to their own national contexts. The information thus collected could be disseminated through technology magazines focusing on development issues of relevance to the countries concerned.

160. An interesting idea was put forward concerning the promotion of international research. It was based on the fact that the detachment of the individual from the world of science and technology may lead to a belief that the latter is an external reality to which attitudes and ways of life have to be adapted. In fact, the process should be exactly opposite. This is because it is human inventive capacity and intellectual activity that modify nature through technology. Thus, up to a point, technology is an extension of the human brain. It is not external to it. The feedback cycle involved in the interaction of man and his own creation should be understood and attitudes should then be induced to change accordingly.

161. An important objective of international co-operation is that of facilitating access to available information of all kinds. Given that the mass of information being generated at present is enormous, access raises the issue of storage, retrieval and the processing of information so as to ensure its relevance to the prevailing conditions in each country. An important role in this connection can be played by the regional structure of Unesco. The ultimate objective of international co-operation should be the establishment and promotion of friendship, unity and equality with a view to safeguarding international peace and enhancing world understanding.

162. The importance of the role of workshops was emphasized as a means of translating into reality some of the thinking of the Congress. Teachers would acquire the knowledge and skills that the 'integrated' approach calls for. Decision-makers and planners would gain a better understanding of the issues involved. Useful material reflecting the international thinking of Unesco and other United Nations agencies, as well as non-governmental organizations, would be produced. Areas of study for workshops could include: science education and nutrition; health; food and agriculture; energy; natural resources; water resources; appropriate technology; and curriculum development.

163. Concerted efforts should be made to strengthen the national capacity to identify and to solve local problems with bilateral assistance, particularly in the area of the training of teacher trainers, who eventually become 'agents de change'. The training of teacher trainers is among the areas of common concern which could also be studied at the regional level, thereby exchanging experiences and expertise in teacher training, the development of educational materials and the dissemination of professional information.

164. There is a growing concern about the ever-increasing cost of training personnel abroad, especially in higher education. The advantage of training locally was emphasized as a way to avoid heterogeneity in the competences acquired by people trained in different countries and institutes, heterogeneity which could render difficult their integration within a given national system. Local training also contributes to a reduction of the brain drain problem.

165. Another means of stimulating development is by properly training primary school teachers, and also by using key groups with influence, such as women's organizations which would collect, discuss and disseminate information.

166. Finally, another key element in development through the educational process was considered to be the training of middle-level technicians with a strong background in up-to-date knowledge of science and technology. This should be done through the establishment of national programmes which would be efficiently co-ordinated and effectively implemented.

167. Bilateral financial support is indispensable for teachers and other professionals if they are to attend and participate in international conferences and workshops where they can get acquainted with what is new and how to teach it, how to produce new teaching materials and simple equipment, etc.

168. Three major issues of great concern were: (a) the co-ordination of efforts by Unesco, other United Nations agencies, intergovernmental organizations and non-governmental organizations; (b) communication between Unesco and national institutions and organizations concerned with science and technology education; and (c) the high cost to the Third World of educational materials and equipment produced in developed countries.

169. Unesco was requested to increase its efforts to secure better co-ordination in the field of science and technology education and co-operation with appropriate national institutions in this field, particularly in the development of educational materials and equipment.

Item 7.3 - <u>The role of Unesco and other United Nations organizations and intergovernmental organizations</u>

170. Representatives from various United Nations organizations (United Nations University, WHO and UNIDO), and intergovernmental organizations (Commonwealth Secretariat, the Arab Bureau of Education for the Gulf States and ALECSO) gave the highlights of their respective programmes in science and technology education. They also expressed their willingness to co-operate with Unesco in various activities for the promotion of science and technology education for national development.

171. The role of Unesco and other United Nations agencies and intergovernmental organizations should be a catalytic one and directed towards the optimal use of limited resources.

172. Various speakers attached considerable importance to improving science and technology education to meet developmental needs in Member States. To this end, attention was drawn to the importance of such factors as socio-cultural relevance, endogenous development, adaptation to the local environment, primary health care and community development, etc.

173. In promoting endogenous development through science and technology education, Unesco's major role should be to seek means of according high priority to raising the capacity and level of performance of local institutions. It was suggested that co-operation should be encouraged through a network of programmes of special concern to the education of the masses and the training of key personnel in various aspects of science and technology education (curriculum designs, teacher education, student testing and programme evaluation).

174. It was pointed out that there is a shortage of teachers and resource people adequately trained to implement and improve science and technology education programmes. To overcome this difficulty Unesco was urged to:

(a) develop innovative training programmes;

(b) develop and use mobile units for the training of science and technology teachers on-the-spot especially in rural areas;

(c) encourage formation of science teachers' associations and/or study groups, especially in countries where such organizations do not exist;

(d) organize study visits and fellowship programmes;

(e) organize studies of the teacher's emerging role and competencies in handling new science and technology curricula;

(f) co-operate with non-governmental organizations at international as well as regional or subregional levels, and support their efforts to promote science and technology education;

(g) encourage research studies which will foster new and urgently required teacher competencies such as self-teaching/learning skills, problem-solving and decision-making abilities, as well as skills for the preparation of self-learning materials and management of learning situations; and

(h) develop resource materials and guides for teachers in the various science disciplines.

175. Another important role of Unesco was that of promoting innovations in science and technology curriculum design and development. The Organization was thus urged to give high priority to teaching the issues which underline global concerns. In co-operation with other intergovernmental organizations (United Nations and others) and non-governmental organizations (international and regional), Unesco was asked to exercise a leadership role in improving science and technology education through the organization of studies, educational research, development of low-cost equipment and pilot or experimental projects, making use of competent local-regional institutions and other organizations.

176. Unesco was also urged to play a special role in facilitating the acquisition, storage, retrieval, analysis and dissemination of ideas and information on science and technology education by strengthening international and regional networking, as well as through meetings, newsletters, etc.

177. In response to the requests of its Member States, Unesco should continue to organize advisory and consultative services for the improvement of science and technology education within the framework of their own developmental policies.

178. Purely academic and compartmentalized education has proved inadequate for survival in an age of science and technology. Unesco, in co-operation with other intergovernmental organizations should play a prominent role in encouraging integrated and interdisciplinary science education and training in relation to industry and technology. Programmes and courses in science and technology education should aim at preparing society for life in peace.

179. Unesco could help to minimize brain drain through the encouragement of suitable educational policies, and the relevant training of individuals, the provision of scientific literature, and other related needs as well as appropriate legislation.

180. Scientific literacy, and the understanding of science and technology are essential for national development. Unesco should, therefore, play a significant role in the promotion of a better understanding of the nature of science and technology and their role in a changing society through the development of relevant, but popular radio/television programmes. It should also support the establishment of mobile exhibitions and museums for the general public. To this end, co-operation between schools, universities and museums should be encouraged with a view to organizing small topical and educational exhibitions.

Item 7.4 - <u>The contribution of non-governmental organizations to the extension and improvement of science and technology education, with special reference to developing countries</u>

181. Representatives of various international and regional non-governmental organizations active in the field of training and science and technology education (IAU, ICSU, WCOTP, IUBS, ICASE, ICSU-CTS, FASE) directed the attention of the Congress to the fundamental part played by non-governmental organizations, cooperating with the organizations of the United Nations system, and to other intergovernmental organizations, in developing science and technology throughout the world, at regional and national levels, particularly in the exchange of ideas and information in the training of human resources and in the development of educational approaches and materials for formal and non-formal education.

182. The pooling of experience, and the sharing of information between teachers and specialists in science and technology, was the priority of international cooperation. The meetings, seminars and conferences organized with the help of non-governmental organizations, both among countries at comparable levels of development and among those at different levels of development, provided a means of helping all to gain access to universal scientific and technological knowledge. This was essential for the growth of international understanding and for the improvement of the material and cultural living conditions of all humanity.

183. A number of participants also drew attention to the crucial role that might be played by non-governmental organizations in the training of human resources required for development. In that connection, it was pointed out that meetings and seminars involving high-level specialists in the field of science and technology had contributed significantly to the encouragement, in both developing and in industrialized countries, of fundamental and applied research necessary to solve the pressing problems confronting humanity. This research included the fields of agriculture, the environment, biotechnology, computer science and the like. Some of these international meetings had had a substantial effect in changing approaches to education and

university research. They had encouraged the spread of interdisciplinary approaches in research. This had led to the generation of knowledge relevant to the practical problems of societies.

184. Attention was also drawn to the part played by non-governmental organizations in furthering the initial and in-service training of teachers. The role of teachers was acknowledge to be one of the keys to development. In that context, reference was made to a number of activities undertaken with the help of non-governmental organizations, such as seminars, training courses and refresher courses especially in the developing countries.

185. Several speakers also drew attention to the contribution that might be made by non-governmental organizations in the development of content and methods in science and technology education. The international composition of these organizations enabled them to bring together the work of specialists in the fields of science and education from various countries and different parts of the world. This placed modern scientific knowledge at the disposal of education relevant to endogenous development.

186. Lastly, all speakers stressed the fact that, if their activities were to be successfully carried on, the financial, technological and logistic collaboration of United Nations organizations, and especially that of Unesco, was essential. They expressed the hope that co-operation would be strengthened in future.

Item 8 - <u>Suggestions for future action</u>

187. Recognizing the importance of national development in its broadest sense, including both material and cultural dimensions, Unesco is encouraged to make greater efforts to promote research and education in inter-disciplinary subjects in order to preserve the cultural heritage and the sound traditions of all nations and peoples of the world.

188. In view of the fundamental role of scientific and technological knowledge in promoting socio-economic and cultural development, and national independence, it is urged that Unesco should continue to promote the access of all countries to the knowledge accumulated by humanity, particularly scientific and technological knowledge. This should be perceived as part of international co-operative action working for the establishment of a world order, founded upon equity and solidarity among peoples.

189. It is proposed that Unesco should seek to clarify the concept of technology education within the framework of general education, particularly the way it should be organized for the purposes of endogenous development. In this connection it is important that the technological component of integrated science teaching should be strengthened at the primary and secondary levels.

190. Having regard to the problems of disseminating the findings of innovative experiments in science and technology teaching, including those problems which arise from language diversity, it was suggested that Unesco should set up an international working group to study their implications and to help Unesco in planning and preparing such publications as international newsletters, annual reviews, etc., which would aim to make new knowledge more widely known.

191. Recognizing that serious problems exist in communication between classroom teachers and sources of needed information, Unesco and national bodies should encourage the use of effective aids to communication including the establishment of local, national and regional centres and clearinghouses in science and technology education. In every country there should be at least one source of information on science and technology teaching whose function would be to promote exchange of ideas.

192. It was also suggested that scientific societies, national teachers' associations and other appropriate national institutions should assist in the circulation of innovative ideas and the conclusions of the Congress. Unesco should support the establishment and the ongoing work of such organizations in all ways possible.

193. Unesco should also promote the pooling of experience in innovative activities, including adaptation of curricula and improved teaching methods by means of publications, seminars, etc. It should augment and strengthen its regional seminars on science and technology education. The scientific and technological components of education should, moreover, be given prominence in regional conferences of Ministers of Education organized by Unesco.

194. In view of the limited financial resources which Member States have for the development of education in general, and of science and technology education in particular, it is suggested that Unesco should strengthen its technical collaboration for the evaluation of activities undertaken by Member States in the field of science and technology education with a view to optimizing and expanding their efforts.

195. Having regard to the role of extramural technological education in the national development of Member States, Unesco is invited also to make use of the 'Union of International Technical Associations' (a category as a non-governmental organization member of Unesco). This union possesses enormous potential for the benefit of developing and industrialized countries.

196. (a) Science and technology are essential for socio-economic and cultural development. The UNCSTD has recognized that development has to have an endogenous character to ensure a reduction of dependency and vulnerability in the case of developing countries. Development has also to be expeditious if the aspirations of the people for meeting even the basic requirements of life are to be fulfilled. There is, therefore, great and urgent need to promote and cultivate science and technology, particularly in the developing countries.

(b) It may be realized that while science and technology are the vehicle for development, education is development itself. It is the human resources of a country with the relevant competencies and creativity which builds its socio-economic and cultural structures and lends a specific quality to the life of the people. Science and technology education, possessing special features which have been widely discussed (and implemented in certain cases) is, by the very nature of scientific knowledge and the associated methods and attitudes, pre-eminently suited to the cultivation of the human resources of the countries concerned. Science and technology education, suitably designed for the school population as well as for out-of-school youth and the public at large, is therefore an inseparable component of a country's developmental effort.

(c) The whole world is engaged in trying to explore ways and means of moving away from traditional science and technology education to an approach that will more effectively cultivate the intellectual, the behavioural, the social and the psychomotor attributes of individuals, while giving them the knowledge and awareness

required for social and economic development. It is imperative that ideas and experiences be exchanged, new materials and systems be disseminated, studies for evaluating them in different societies be undertaken, and assistance be provided to countries and people for developing their own approaches to new science and technology education.

(d) Conferences sponsored by United Nations agencies and learned societies have played a very significant role during the last few decades. But now there are enough basic resources available to push the pace of development by concerted and organized effort, so that the pressing needs of the developing countries are met in time.

(e) The Congress, therefore, suggests that Unesco should provide, within its Medium-Term Plan (1984-1989) in the field of education, an international programme for the promotion of co-operation between Member States in the field of science and technology education, with special reference to the needs of developing countries. The scope of the programme will include primary, secondary and post-secondary science and technology education, teacher education, non-formal and continuing education, and the public understanding of science and technology.

This programme would promote:

(i) the development of relevant curricula, materials and equipment;

(ii) the exchange of information, experience and materials;

(iii) research, evaluation, studies and experimentation;

(iv) the training of personnel, particularly teachers;

(v) the dissemination of information pertaining to such programmes and activities;

(vi) the mobilization of resources;

(vii) the formation of national groups for science and technology education.

Suitable methods may be adopted in the programme to carry out these activities, with the help of a network of co-operating national institutions and international or regional scientific organizations concerned with science and technology education.

It is further recommended that an international centre for science and technology education should be set up, preferably in a developing country, so as to institutionalize and facilitate the operation of such a programme.

(f) The Congress urges other inter-governmental and non-governmental organizations to contribute, each according to its sphere of work and speciality, in implementing the suggestions contained in the report of the Congress.

(g) The Congress strongly recommends that national governments in developing countries should set up policy-making, planning and implementation groups in the sphere of science and technology education so that national and international efforts may be most effectively channelled towards the endogenous development of each country.

197. In view of the importance of safeguarding the peace necessary for development, in which science and technology, as well as science and technology education, play an important role, Unesco should study the possibility of setting up a competent international committee, composed of eminent scientists and educators which would consider the vital necessity of working for peace, disarmament and the prevention of a nuclear catastrophe. The conclusions of such a committee would be disseminated worldwide.

ANNEX I

# PROGRAMME

Registration

1. Opening Ceremony

   Address by the Representative of the Director-General

2. Election of the Chairman

3. Election of Vice-Chairman, Rapporteur and Vice-Rapporteur

4. Election of Chairmen of four working Commissions

5. The Role of Science and Technology Education in National Development

   5.1 National development goals: the contribution of science and technology education.

   5.2 The contribution of science and technology education to the solution of some major contemporary problems in relation to development.

   5.3 Future trends in science and technology and their implications for science and technology education in the context of national development.

   5.4 Implications of the UNCSTD conference for education in science and technology.

6. Strategies for the Improvement of Science and Technology Education in relation to Development, including suggestions for Future Action

   6.1 The contribution of education to building up a favourable climate for the development and application of science and technology.

   6.2 Science and technology education in the perspective of development needs.

   6.3 Development of content, methods and materials for science and technology education.

   6.4 Promotion of the endogenous development of science and technology education.

7. International Co-operation

   7.1 Main issues and objectives of international co-operation in science and technology education.

   7.2 Main areas and methods of international co-operation in this field.

7.3 The role of Unesco and other organizations of the United Nations system and inter-governmental organizations.

7.4 The contribution of non-governmental organizations to the extension and improvement of science and technology education, with special reference to developing countries.

8. Suggestions for future action

(national, regional and international)

Presentation and adoption of the final document.

Closing ceremony

ANNEX II

# ADDRESS BY THE ASSISTANT DIRECTOR-GENERAL FOR EDUCATION AT THE CLOSING MEETING OF THE INTERNATIONAL CONGRESS ON SCIENCE AND TECHNOLOGY EDUCATION AND NATIONAL DEVELOPMENT

(Paris, 2 December 1981)

ANNEX II

Mr. Chairman,

Ladies and Gentlemen,

At the close of the International Congress on Science and Technology Education and National Development to which you have devoted long hours of hard work over the last ten days, I would like to thank you on behalf of the Director-General and on my own behalf for the way in which you have fulfilled the expectations of the Organization. My thanks are due, first of all, to the Chairman of the Congress, Mr. Rais Ahmed, who conducted your plenary discussions with great authority and distinction, to the three Vice-Chairman, Mr. Chimombe, Dr. Lockard, and Academician Razumovski, and to the Rapporteur, Professor Za'rour and the Vice-Rapporteur, Dr. King, who have set out the results of your work in an excellent document. I also wish to express my gratitude to the Chairmen of the four commissions, Professor Taylor, Ms. Krasilchik, Professor Soos and Dr. Fall, to the Vice-Chairmen, Dr. Hernandez, Dr. Sangster, Dr. Silin and Professor Pei-Ji Xie and to the four Rapporteurs, Professor Eshiwani, Dr. Fekih, Dr. Tobon and Dr. Orpwood, for the great deal of work they have done. To tell the truth, however, my thanks must go to you all for having so consistently maintained the high standard of your deliberations and contributions.

I believe that this Congress has amplified and clarified some of the points covered in the Programme of Action adopted by the United Nations Conference on Science and Technology for Development which met at Vienna in 1979. Owing to its s success, it is now possible to attain completely the objective set out in the Programme that was approved at the twenty-first sessions of the General Conference of Unesco - the Organization which, by virtue of its constitutional responsibilities, has a leading role to play within the United Nations system in the sphere of science and technology education.

I hope that you have taken advantage of the opportunities afforded by this Congress for exchanges of views and I am sure that the information which you have supplied on current trends in the field under consideration and the suggestions which you have made as to guidance to be given on measures to be taken in order to improve science and technology education will prove invaluable to all who share this concern: government officials, national institutions or associations, international governmental and non-governmental organizations and, of course, Unesco.

You have confirmed, as a matter of course, that science and technology education have an important role to play in national development. You have paid attention once more to the fact that the developing countries should not only have access to the international community's store of scientific and technological knowledge so as to use it after adapting it to their own needs, but should also have the necessary means for developing their own potential for producing new knowledge, even in the most advanced fields of research and technology. It is with this in mind that one of you has said that there is no such thing as "relevant technology" but only "technologies relevant to needs", meaning thereby that the idea of "inferior" technologies should be dismissed once and for all.

As was pointed out in one of the information documents made available to you, the Vienna Conference had perhaps placed too much emphasis on scientific and technological

training at the expense of science and technology education. It seems to me that your discussions have fortunately corrected this tendency by redefining all the aims of science and technology education in relation to national development. The training of researchers, scientists and technicians is essential of course, if countries are to be provided with qualified personnel capable of continually developing their skills. But you have thought it important to define the broad aims of science and technology education. You have reiterated the principle that it should seek to prepare the student for his future life and for productive work and to enable everyone to contribute to the solution of practical problems and the improvement of living conditions. You have emphasized that science and technology education is important not only because it lays the foundations of a scientific understanding of the natural universe and the man-made world, but also because it provides people with the means for making wiser decisions on problems concerning the different aspects of social and economic life. You have rightly pointed out, in fact, that science and technology education is an invaluable element of intellectual development and should accordingly form an integral part of any course of general education.

One of the conclusions of your discussions which has struck me most forcibly is that it is not enough to develop science and technology education as a separate entity. You have maintained on the one hand that no general education can meet the needs of the modern world unless it includes science and technology education at all levels among the essential factors in the all-round development of the pupils' personalities and in the process of preparing individuals to play their roles in society; and, on the other hand, that science and technology education cannot be separated from the other elements of a complete education, and least of all from the ethical and cultural aspects thereof. Many participants have highlighted this reciprocal relationship in which science and technology, as carriers of cultural values, influence culture but must themselves become permeated by that culture if they are to contribute to endogenous development. Several of you have recalled that the use of mother tongues and national languages is one of the ways of putting science and technology at the service of endogenous development and implanting scientific and technological culture in national traditions. While you have brought out the role of science and technology education as a factor of modernization, you have also noted that traditional technologies could often be profitably integrated into scientific and technological development. You have thereby raised the question of the building of that modern humanism which should reconcile and combine traditions holding promise for the future with newly acquired knowledge. This question concerns all Member States in varying degrees but is obviously of capital importance for the developing countries.

I attach special importance, in the light of the Unesco constitution, to the references you have made to the dangers to peace represented by certain uses of science and technology and particularly to the menace of a nuclear catastrophe. It is natural that you should have mentioned the duty of the international scientific community to make the public at large aware of these perils and that you should have expressed the hope to see that community organize itself in order to do so. Just as naturally, therefore, you have laid stress on the need to make every possible effort to preserve the peace and on the role which education is called upon to play in this regard.

You have shown that it is not enough to give science and technology education a more prominent place in curricula, but that the whole question of the spirit in which it is dispensed needs to be rethought, together with that of its links with the other subjects taught. You have expressed the opinion that science and technology education should not be exclusively concerned with the cognitive content of curricula

but should also foster the pupils' personal attitudes and aptitudes such as creativity, a capacity for practical action, a liking for socially useful work and, more particularly, productive work, a sense of responsibility and a respect for the experimental method of testing hypotheses. It should, moreover, pay much greater attention to the development of the pupils' reasoning faculties, their understanding of concepts, the awakening of their intellectual curiosity and their awareness of the importance of observation and experimentation, than to their memorization of facts and theories out of the context of their practical significance and applications.

You have held an illuminating discussion on the links between the teaching of mathematics and science and technology education. You have indicated the place that should be assigned to an introduction to informatics which, in your opinion, should not be taught as a separate discipline, except, of course, when it is a matter of training specialists.

It was essential to bear these general considerations in mind in order to define the spirit in which science and technology education should be approached if it is to become an integral part of an all-round and socially relevant education. It was also necessary to recall, as you have done, that education, although a discipline in its own right, is one of the sub-systems of society and that social relevance is assured only if it always pays attention to the particular characteristics of each natural and cultural environment. You have accordingly endeavoured to show how science and technology education should be tied in with the various kinds of productive work, should call on the help of people outside the teaching profession and should associate the different social groups within the community, which are both producers and consumers of knowledge in the formulation and implementation of programming and activities concerned with science and technology education.

I must also congratulate you on having made clear [illegible] the light of a more detailed analysis which was entrusted mainly to the Co[illegible]sions, what conclusions should be drawn from these general principles for the different levels of formal education, for out-of-school activities and for the promotion of public understanding of science and technology. Reflecting on the two lines of approach to scientific work which are currently developing, namely the trend towards integration and the trend towards an even deeper specialization, the latter being accelerated by the progress of new sciences and technologies, you have defined the extent to which you think science education should be integrated or diversified, disciplinary or inter-disciplinary, at each level, and you have accordingly made very helpful suggestions for the planning of syllabuses. You have noted that children should be given a scientific vision of the world as soon as they enter primary school, where they should be introduced to the perception and observation of concrete applications of science and technology. You have rightly said that one of the tasks of primary education is to arouse in very young children an interest in taking up scientific and technical work.

You have also stated that, given the fast pace of the progress of knowledge in this field and the speed with which the related social changes are taking place, no knowledge is even acquired once and for all, and that it is particularly important here, both from the standpoint of general education and from that of professional competence, to make provision for the updating of knowledge and the re-training of staff. You have thus recognized the importance of science and technology education in the context of lifelong education.

The retraining principle applies, of course, to teachers and even, as you have said, to all educationists. It goes without saying, as you have pointed out, that continuing education, like initial teacher training, is one of the keys to a system

of science and technology education so designed as to be capable of playing its proper role in the development process.

You have made judicious and constructive comments on the equipment needed for a system of education so designed, on its high cost, on material obstacles and on the inadequacy of resources, and I welcome your enumeration of the problems arising in connection with efforts to establish the national infra-structures required in order to develop science and technology along the lines you have indicated. Your comprehensive list of measures to be taken and your suggestions regarding certain specific arrangements to be made constitute a set of proposals in which every one concerned with this problem in Member States and throughout the international community will find valuable guidance. As far as the Director-General is concerned, I can assure you that he will give them his closest attention.

The very magnitude of the efforts to be made, as well as the fact that many experiments are in progress, on which your discussions have provided much information, have brought to the fore the need to intensify regional and international co-operation in order to further the advancement of science and technology education and that of the whole of education in the service of development. The importance you have attached to promoting broadly-based co-operation at all levels makes it quite clear that, in your view, endogenous development does not mean that every country closes in on itself but, on the contrary, that it incorporates into the national tradition the contributions of an international community of which it is an integral part and which it can itself enrich with its own experience. You have visualized this co-operation as a dual system of wide-ranging exchanges between countries belonging to the same region, on the one hand, and between different regions on the other hand.

You have stressed the need to organize on-the-spot training whenever possible and to adapt training courses provided abroad, especially at the post-graduate level, to the requirements of each student's country of origin. This will remove one of the causes of the brain drain, which represents a serious loss of human and financial resources for the developing countries.

You have been right, in my opinion, to make some suggestions which, as they are consistent with the responsibilities of the industrialized countries towards the developing countries, may induce the latter to ask the best endowed countries to help them develop their national training, research or equipment production capacities.

You have called for a wide-ranging exchange of experiences, the dissemination of more information and the intensification of co-operation in research and development. You have expressed the hope that optimum use will be made of innovative education programmes such as those which Unesco has endeavoured to set up. You have recalled that Unesco is particularly well placed to provide the framework for co-operation in this field. Your excellent contributions to the discussion and your very practical suggestions have shed a new light on various aspects of the problem of improving science and technology education, which is an important factor in development and a major field of international co-operation.

On behalf of the Director General and on my own behalf, I congratulate you very warmly on the success of your work and wish you all a safe return to your respective countries.

## ANNEX III

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## LIST OF DOCUMENTS

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| ED-81/CONF.401/4 | Strategies for the Improvement of Science and Technology Education in Relation to Development, including Suggestions for Future Action -- Working Document for Commissions |
| ED-81/CONF.401/INF.1 | Some Significant Trends and Recent Activities in Science and Technology Education in Africa, Arab States, Asia and Latin America |
| ED-81/CONF.401/INF.2 | Implications of the 'United Nations Conference on Science and Technology for Development' (UNCSTD) for Education in Science and Technology |
| ED-81/CONF.401/INF.3 | Report of the Second Meeting of the Advisory Panel on Science, Technology and Society (Paris, 31 August -- 3 September 1981) (SC/631/07) |
| ED-81/CONF.401/INF.4 | Unesco's Activities in Science and Technology Education |
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